Section 1: Introduction

Hazard Mitigation

In the context of natural disasters, ***hazard mitigation***[1] is commonly defined as any sustained action that permanently reduces or eliminates long-term risk to people, property, and resources from natural hazards and their effects.

In the context of this Local Pre-Disaster Mitigation (PDM) Plan ***hazard*** refers to an extreme natural event that poses a risk to people, infrastructure, or resources. ***Risk*** can be defined as "hazard; danger; peril; exposure to loss, injury, or destruction" or "the possibility of suffering harm or loss." The Town's hazard risk assessment determines which areas of Eastham may be affected by a natural hazard, how likely it is that a given hazard may occur, and how intense that hazard might be.

Vulnerability can be defined as "susceptibility to injury or attack." Vulnerability indicates what is likely to be damaged by the identified hazards and how severe the damage might be. For example, if an area is determined to be at risk of flooding, vulnerability estimates could include potential residential property losses, impacts to the tax base and damages to public infrastructure in that area.

Hazard mitigation planning is the process that the Local Multiple Hazard Community Planning Team underwent to analyze our Town's risk from natural hazards, to coordinate available resources, and to develop a strategy to implement actions to eliminate risk.

Plan Benefits

The purpose of Eastham's *Pre-Disaster Mitigation (PDM) Plan* is to fulfill the local hazard mitigation planning requirements of the federal *Disaster Mitigation Act of 2000 (DMA 2000), Section 322 (a-d)*. The PDM Plan identifies hazards; establishes local goals and objectives and selects mitigation activities that are appropriate for the Town of Eastham. The DMA 2000 requires that local governments, as a condition of receiving federal disaster mitigation funds, adopt a PDM Plan describing the municipalities process for identifying hazards, risks and vulnerabilities, identifying and prioritizing mitigation actions, encouraging the development of local mitigation and providing technical support for those efforts.

Planning Process

On, June 2, 2003, the Eastham Board of Selectmen established the Local Multiple Hazard Community Planning Team (the "Planning Team") consisting of two members of the Board of Selectmen, the Police Chief, Department of Public Works Superintendent, Building Inspector, Health Agent and Town Planner.

[1] Definitions and text adapted from "Strategy for Reducing Risks from Natural Hazards in Narragansett, Rhode Island: A Multi-Hazard Mitigation Strategy, June 1999" and the Barnstable County PDM Plan.

Planning Team members are listed in Table 1. Activities and research were also coordinated with the Town's Natural Resources Department, Harbormaster and Fire Department. In the future, as the Town moves forward in implementing the recommendations of this PDM Plan, the Planning Team may be expanded to include Conservation Commissioners and members of the general public.

Table 1: Eastham's Local Multiple Hazard Community Planning Team

Linda Burt, Chair Eastham Board of Selectmen 2500 State Highway Eastham, MA 02642 (508) 240-5900	Frank DeFelice, Building Inspector Eastham Building Department 2500 State Highway Eastham, MA 02642 (508) 240-5900 x 228
Ken Collins, Member Eastham Board of Selectmen 2500 State Highway Eastham, MA 02642 (508) 240-5900	Jane Crowley, Health Agent Eastham Board of Health 2500 State Highway Eastham, MA 02642 (508) 240-5900 x 229
Richard Hedlund, Chief Eastham Police Department 2550 State Highway Eastham, MA 02642 (508) 255-0551	Terry Whalen, Town Planner Eastham Planning Department 2500 State Highway Eastham, MA 02642 (508) 240-5900 x 202
Steve Douglas, Superintendent Department of Public Works 555 Old Orchard Road Eastham, MA 02642 (508) 240-5973	Other Members Added as Necessary

The PDM Plan was developed locally within a regional context with guidance from the Regional Planning Agency (RPA) or Cape Cod Commission (CCC). A Planning Team representative attended bi-monthly Pre Disaster Mitigation (PDM) workshops sponsored by the CCC to provide local municipalities with a framework and resources to develop a local plan. Planning Team members would typically meet after bi-weekly, Town Department Head meetings to work on task assignments to move forward on developing a Draft PDM Plan.

Upon completion of the Draft PDM Plan, the general public was included in developing and reviewing Eastham's PDM Plan. At a public meeting held on October 4, 2004 the draft plan was presented the general public at a meeting of the Board of Selectmen, while the draft plan was concurrently posted on the Town's website and available for review at the Planning Department for a public comment period. Responses to comments on the Draft PDM Plan are included in Appendix A of this document. All comments received were evaluated and incorporated into the final plan as applicable.

The final PDM Plan was adopted by the Eastham Board of Selectmen after the close of the public comment period and incorporation of applicable comments on October 20, 2004. Further opportunities for public involvement will continue as identified Action Items are implemented including: participation in program development, serving as citizen representatives on a local hazard mitigation panel, attending public hearings, working as citizen volunteers to educate other individuals about the PDM Plan, assisting in program coordination with other pre-existing programs, supporting hazard mitigation related Warrant Articles at Town Meeting or participating in other volunteer efforts.

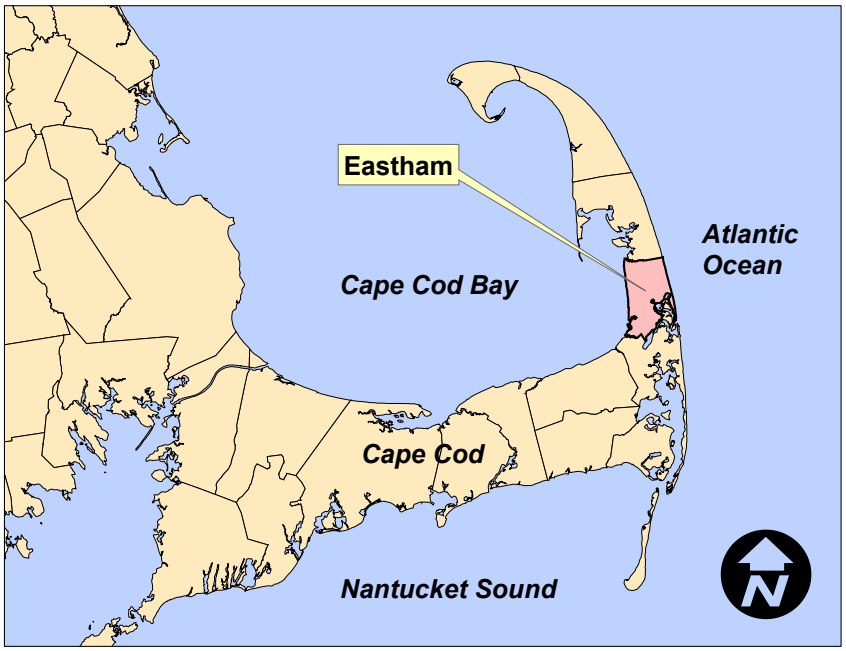
Eastham Conditions

The Town of Eastham is located on a strip of land lying across the base of the "outer arm" of Cape Cod in Massachusetts. Eastham is approximately three (3) miles wide from east to west and approximately seven (7) miles long from north to south. The Town is bounded to the north by the Town of Wellfleet, on the south by the Town of Orleans, on the west by Cape Cod Bay and on the east by the Atlantic Ocean (Figure 1).

Eastham encompasses a total area of approximately 27 square miles, an upland area of approximately 14 square miles and has over 37 miles of tidal shoreline. The Town is located approximately 99 miles southeast of Boston, 96 miles east of Providence, Rhode Island and 25 miles east of Hyannis.

The Cape Cod National Seashore, authorized by Congress in 1961, comprises one-third of Eastham's area (3,000 acres), including most of its six and one-half (6½) mile Atlantic Ocean shoreline, stretching from Orleans to Wellfleet.

Figure 1: Eastham Location Map



Climate

Eastham experiences the New England humid continental climate, characterized by a moderate to wide annual temperature range with well developed winter and summer seasons with average winter temperatures ranging between 27°F and 41°F rising to a summer average range of 56°F to 78°F. However, the July average daily maximum is from two to three degrees lower on the Cape than inland areas due to the cooling effect of summer afternoon breezes. The ocean also serves as a reservoir of warmth in the winter as January and February average daily temperatures are several degrees warmer than that of mainland Massachusetts.

Annual precipitation averages 48 inches, occurring on an average of 120 days and fairly evenly distributed throughout the year. Receiving an average of 37 inches of snow in 17 days, the Cape can also experience severe winter coastal storms (northeasters), with strong northeast winds, low clouds and a steady driving rain or snow. Of the 48 inches of average precipitation, approximately 16 inches filters through to replenish the water table.

With an average humidity of 75 percent, fog is relatively frequent and dense due to the cooler ocean water surface temperatures in the summer, which tends to reduce formation of strong vertical air movements. Thunderstorms are less common over the Cape than over the mainland.

Geology

Cape Cod and Eastham owes its existence to glacial deposits derived from the last ice sheet which moved over southeastern New England. Glauconite, fossil material, and the sparsity of feldspar in the glacial sand suggest that the ice sheet overrode coastal plain and shelf sediments of Pleistocene and pre-Pleistocene age before reaching Cape Cod. During deglaciation of southern New England, the topography of the continental shelf played a major role in determining the pattern of ice retreat. Major lobes formed in the relatively shallow basins on the shelf.

Soils

The climatically associated soils on Cape Cod are podzols. Their existence in this less than normal hostile climate is due to the porosity of the glacial material and the rapid leaching associated with it. The remaining sediments that are characteristic of the Eastham area are interior and coastal sands deposited by wind actions either along the present coast and associated with wave action or those sands associated with direct glacial deposition. Wet sediments found in and near salt marshes and freshwater swamps are also quite prevalent, particularly in southern and coastal Eastham areas.

Topography

Like most of Cape Cod, Eastham's terrain is level to gently rolling with land mass elevations generally from sea level to sixty feet above sea level. Perhaps the most significant feature of the topography is the nearly one half of the Town covered by water. Eastham might be considered the "low country" of the Cape, with many points of saltwater infiltration occurring at elevations below sea level. The most dramatic topographical features occur along the Atlantic Ocean coast where steep cliffs or bluffs are formed by the erosion of sand dunes.

Population Trends

The population of the Town of Eastham has grown steadily and substantially for many years. More recently, from 1970 to 2000, it has increased from 2,043 to 5,453. Even during the most recent decade it has grown another twenty-two percent (22%). The special characteristics of Eastham's population have a special impact on the community. The resident population has gotten older. The median age remained fairly steady from 1970 to 1990 and increased substantially during the nineties from 41.7 years to 47.6 years in 2000. Furthermore, there is a larger and growing seasonal component ("shoulder" season) in the summer population. In 1990 the daily summer population was estimated to be 21,800 and by 2000 it was conservatively estimated to be 27,500. This is a twenty-six percent increase as compared with the twenty-two percent increase in the resident population over the same time period. The Eastham Police Department, which annually projects daily summer population, estimates the 2004 value to be approximately 30,000.

These dramatic changes in Eastham's population are supported by increasing income, increased mobility of people, the draw of the National Seashore and other natural attractions as well as by the general appeal of the character of the community. Such growth and changes in population impacts the use of the land and relationships with natural systems. The management of the responses to these developments will determine the extent to which the mission and goals of this plan are achieved.

The likely impacts felt in the Town by this projected growth in population will include increased local and through traffic, demand for additional services and pressure for additional residential development, including the conversion of seasonal homes to year-round homes. Eastham's population has increased by an additional twenty-two percent or 991 people, between the years 1990 and 2000. The town's population is projected to continue to increase to 7,280 by 2010.

It should also be noted that the population projection does not account for potential conversion of over 3,000 existing seasonal homes to year-round dwelling units. Although the rates of conversion have not been predicted there is evidence to show that such conversions have been occurring. The United States Bureau of the Census reports that in 2000 more that 43% of all housing units were occupied year-round while in 1990 the comparable ratio was only 39%. There is a movement toward year-round use of housing. "Conversion" is a matter of use or occupancy. Other factors which could influence conversions include improved transportation and communications and the continued growth of the surrounding areas. The full conversion of seasonal to year-round housing units would have twice the potential impact on Eastham's municipal infrastructure, services and finances than would result with the complete development of the remaining vacant residential land in town.

Existing and Future Development Patterns

There are approximately 1,200 acres of vacant developable land with the potential for additional residential development. The potential residential buildout for Eastham under the current zoning is approximately 734 additional housing units resulting in a total of 6,000 units at buildout. Over the last 25 years Eastham has averaged 103 new housing units per year. Using that average rate, Eastham could reach residential buildout in 2006. The buildout figures do not account for approximately 400 grandfathered lots that are below the current zoning requirements but are protected under MGL.Ch.40A. While these grandfathered lots could be built without regard to

current zoning, they are subject to other Town by-laws and regulations. That, combined with the lack of sewer or water service, will reduce the number of potential units.

There are approximately 37 acres of commercial land and 25 acres of industrial land available for development. If all the land is used, there could be eleven and one-half (11.5) acres or about five hundred thousand (500,000) square feet of gross floor area of commercial development and seven and one-half (7.5) acres or about three hundred and twenty-seven thousand (327,000) square feet of gross floor area of industrial development. It should be noted that most of the vacant industrial land has inadequate access at this time due to lack of frontage on a private way.

Major challenges face the Town including whether future development will change the character of Eastham, and how to pay for the increased demands placed on municipal services by the development of the remaining vacant land and conversion of seasonal to year-round housing units. The configuration of the Town, its existing land use pattern, traffic volume along Route 6, fiscal constraints and lack of a public water supply or wastewater disposal limits the options. Presently land use development is guided by local ordinances, in accordance with the MGL Chapter 40A (The Zoning Act) and MGL Chapter 81 (The Subdivision Control Law).

In the context of hazard mitigation planning, the current population and seasonal visitation trends coupled with a diminishing amount of easily developable land with minimal constraints will place increasing pressure on lands considered marginally developable. Additionally, the dense development patterns established prior to enactment of zoning controls on the western side of Town near Cape Cod Bay will also face considerable redevelopment pressures, often in environmentally sensitive areas. Continued oversight of development and redevelopment in areas adjacent to coastal water bodies/marshes, as well as those adjacent to inland Wetland Resource Areas, will be critical to eliminate and mitigate the potential for losses as a result of natural hazards.

Town Goals Supporting Hazard Mitigation

While hazard mitigation is not explicitly mentioned as a guiding principle in the Local Comprehensive Plan (LCP) or Open Space and Recreation Plan (OSRP), components of such an approach are indicated in various goals, performance standards and recommendations found in both of these documents. Additionally, the Board of Selectmen have consistently supported Town Meeting Articles to purchase or acquire (land swaps) parcels containing both sensitive wetlands and floodplain on portions of the property for conservation purposes, removing them from future potential development and creating potential hazards.

The practice of acquiring environmentally sensitive lands, has resulted in many acres being removed from potential development and the corresponding placement of structures in locations susceptible to damage from natural hazards.

Eastham's Goals for Hazard Mitigation

The PDM Plan identifies the six (6) goals established by the Town of Eastham for purposes of developing a strategy to implement actions to eliminate risk. Each Goal statement is meant to be general and broad in nature and can only be achieved through the long-term implementation of more specific objectives. Each Goal listed below will be more specifically addressed and realized through the implementation of an Action Plan, defining short-term mitigation objectives and actions established and maintained in *Section 5: Mitigation Strategy*. The goals of Eastham's PDM Plan are as follows:

Goal #1 - Reduce the potential for loss of life, property, infrastructure, and environmental and cultural resources in Eastham from natural disasters.

Goal #2 - Coordinate local hazard mitigation planning activities with those of Barnstable County and neighboring towns.

Goal #3 - Seek for and take advantage of funding opportunities to implement the Plan.

Goal #4 - Mitigate potential financial losses incurred by municipal, residential and commercial establishments due to disasters.

Goal #5 - Ensure that mitigation measures are context sensitive to natural features, historic resources, and community character.

Goal #6 - Increase the public awareness of existing hazards and encourage hazard mitigation planning as part of the overall municipal planning process.

Section 2: Hazard Analysis and Risk Assessment

Geographical Position

The Town of Eastham is vulnerable to a host of hazards including hurricanes, earthquakes, coastal and inland flooding, culvert/bridge failure, wildfires, drought, and winter storms,. Although the Eastham is most vulnerable to hurricanes, severe winter storms, and floods. Other hazards pose potential risks to the Town's population and property. To spatially evaluate the range of potential hazards to conduct a risk analysis, a series of maps were developed by the CCC and reviewed by the Planning Team. The content of those maps is described in the following section.

Hazard Mapping

Risk and Vulnerability Assessment – This map depicts the locations of critical facilities and infrastructure, Med Flight locations, extent of "A" and "V" flood zones, Repetitive Loss properties, evacuation routes and indication of facilities located Sea, Lake and Overland Surges from Hurricanes or SLOSH zones. Critical facilities were also grouped into functional areas (i.e., shelters, public safety facilities, etc.).

Hazard Risk Map 1 – Historical occurrences of tornadoes, earthquakes, landslides and shoreline change are noted on this map.

Hazard Risk Map 2 – This map indicates average annual snowfall amounts and tracks of hurricanes in the Eastham vicinity.

Hazard Risk Map 3 – Local areas of wildfire risk and the wildland/urban interface are mapped and relationships with residentially and commercially developed areas are also indicated.

Historical Damage/Events

Winter Storms

Review of historical accounts point to the winters of 1716, 1874-1875 and 1978 having significant distinguishing characteristics. Sidney Perley's 1891 classic book chronicled every major New England weather event. Perley noted, *'Snow fell in considerable quantities several times during the month of January, and on February 6 it lay in drifts in some places twenty-five feet deep, and in the woods a yard or more on the level.'*

In more recent memory, the Blizzard of 1978, referred to some as the 'Storm of the Century' wreaked havoc along the Cape and Eastham in particular. At Coast Guard Beach in Eastham, storm surges from the storm breached the dune line, flattening 90 percent of the dunes themselves, carrying out most of the beach cottages, including Henry Beston's Outermost House. This storm totally destroyed a bathhouse and parking lot. The Blizzard of 1978 still holds the record for the highest storm total and 24 hour total snowfall ever in February. In this storm 23.6 inches of snow fell in 24 hours (Laurel Guadazno, Provincetown Banner).

Hurricanes

Eastham's maritime position adjacent to the Atlantic Ocean, makes is most vulnerable to hurricanes between June and October. Recent hurricanes which have made landfall near the Cape are Gloria (1986) and Bob (1991). The probability of a hurricane occurring on the outer Cape is approximately 7 percent for any given year (Simpson and Lawrence, 1971). Despite the fact that the eye of Hurricane Bob in 1991 missed Eastham by almost 100 miles, tree damage was severe and electric service was lost for up to ten (10) days in some locations.

Erosion

The average rate of erosion along the Atlantic shore is about 3.1 feet per year (Ziegler et al, 1964); along the Cape Cod Bay shore it is somewhat less. Major changes in the shoreline resulting from erosion and deposition occur primarily during storm events coupled with "spring" tides. When erosion threatens structures which are not easily relocated, such as the numerous cottages along the Cape Cod Bay cliffs, property owners have sought to stabilize the bank with engineered structures such as bulkheads or revetments. The net effect of these structures is to reduce the amount of sand available to the beach and consequently the barrier beaches at Sunken Meadow and First Encounter. Various alternatives have been utilized, such as nourishment using sand from inland sources, "soft" solutions using sand bags; vegetative cover and sand drift fencing.

Recent changes in the offshore sand bars near Nauset Light Beach have resulted in accelerated erosion. As a result, the lighthouse structure was in danger of collapsing into the sea. A coordinated effort of private citizens, the Cape Cod National Seashore and the United States Coast Guard provided for the safe removal of the structure to a more landward location in the fall of 1996. Erosion along the dune at Coast Guard Beach in 1992 revealed artifacts of an encampment. A team of National Park Service (NPS) archaeologists completed a detailed examination of the site over a period of ten (10) months and documented valuable information about the inhabitants some 8,000 years ago.

Floods

Eastham, because of its coastal New England location, is highly susceptible to northeasters. A northeaster travels in a southwest to northeast direction along the Atlantic coast collecting moisture over the ocean and sending it inland via northeast winds. Northeasters differ from hurricanes in that they cover a large area. While a hurricane may last for several hours, a northeaster may last for several days; therefore northeasters usually are accompanied by at least one (1) high tide, increasing the severity of coastal flooding.

In addition to flooding, damaging waves may accompany the tidal surge in coastal areas. Both the eastern and western shorelines of Eastham are subject to wave action. The storm of 1978 has been designated approximately a 100 year event, causing inundation along much of Eastham's shoreline below elevations of ten (10) to twelve (12) feet. The strength of this storm was demonstrated by the loss of public beach area and the parking lot at Coast Guard Beach on the Atlantic Ocean.

The dunes and the bath house at Coast Guard Beach were also lost to the attacking waves, while the storm surge inundated the bike trail bridge. Storm waters washed many locations at Nauset

spit carrying away houses and eroding dunes. At Nauset Light Beach, waves eroded the base of the cliffs, causing some damage to the parking lot. Many areas were inundated by the storm surge including the parking area at Rock Harbor, houses along Town Cove on Ellis Road and portions of Bridge Road.

During the Storm of January 9, 1978, the bayside beaches suffered erosion due to gale force winds from the southwest occurring at the peak of the tide. These areas suffered further damage during the February storm from the tidal surge which elevated waters at least three feet above the normal high tide. Winds, however, were from the northeast at the time of the peak tides; therefore, waves were not generated that would damage south and west facing shorelines.

In October of 1991, the so called "Perfect Storm" formed in the Atlantic Ocean as a result of three storm systems combining into one massive storm. As this storm traveled off the coast of Cape Cod, strong storm surf, driving rain and associated high winds, with gusts above hurricane force recorded at Chatham, damage rivaling the "Blizzard of 78" was experienced. Along the western shore of Town Cove, flooding at Collins Cottages far exceeded that associated with the "Blizzard of 78" by over 20 inches, with close to 4 ½ feet of water flooding the "shucking house" and the lower level of the main house above the existing seawall on the site. Additionally State Highway (Route 6) flooded in the vicinity of Mary Chase Marsh and was closed for approximately two (2) hours.

Shoreline Change

The alignment of the seaward shore of Nauset Beach and the cliffs cut in the glacial deposits to the north suggest that the shoreline is retreating westward at a constant rate. Material eroded from the glacial deposits is transported by waves and currents and deposited at the distal end of the spits as shoals or beach deposits. During storms the seaward shore of the spits is eroded and beach deposits are deposited several feet above normal high tide. Locally, storm waves cut channels (storm sluices) through the spits and dunes, carrying material into the lagoon where it is deposited as over wash fans which re-vegetate in succeeding seasons.

Recent, generalized long-term shoreline change mapping indicates Eastham's Atlantic shoreline is eroding at a rate of greater than two (2) feet per year. Shoreline change along the Cape Cod Bay shoreline ranges between zero (0) – one (1) and one (1) – two (2) feet per year.

Shoaling

Sea cliff erosion of glacial deposits and long shore transport of beach sand provide sediment for the growth of spits in the Ocean and sediment deposition in the Bay. The location of Nauset Inlet is a dynamic entity, subject to seasonal tidal cycles, weather patterns and episodic storm events. The entrance to Rock Harbor Creek, is subject to sediment deposition over time, reducing the depth of its navigation channel.

Wildfire

The three principal factors affecting wildfires are topography, fuel and weather. A fire's rate of spread varies directly with wind velocity. Other hazards may trigger wildfires, and wildfires may contribute to other hazards. For example, high winds can result in downed power lines, which can start fires.

Due to the large amount of contiguous undeveloped land, mostly with the boundary of the National Seashore, significant potential for wildfire exists in Eastham. Lack of a municipal water supply adds concerns and highlights the needs to coordinate closely with the National Seashore on responses and mitigative actions to wildfire threats. Special attention should be given to areas of the urban/wildland interface where vegetation and the built environment provide fuel. National Seashore data indicates an average of 10.7 wildfires per year, mostly attributable to campfires and unknown causes.

Drought

A drought can best be described as a deficiency of rainfall causing a shortage of available water. Droughts can result in inadequate levels of water available for residential, commercial, recreational uses and fire fighting. The Cape is perceived as "water-rich", however, it can experience extended periods of dry weather, from single season events to multi-year events. As recently as 2002 and early 2003, The Massachusetts Drought Management Task Force - a multi-agency coordinating body, issued a Drought Advisory for the Cape and Islands Region as a result of long-term below normal groundwater levels. However, no known water supply shortages have been linked to any prolonged dry periods to date.

Hazard Analysis

Hazard Identification

Historically, the Town of Eastham has sustained damage from flooding, storm tides/surges, and high winds associated with hurricanes, nor'easters, and heavy rains. However, this PDM Plan and its mitigation strategy addresses multiple natural hazards, even those assessed with low probability. As part of the development of this Plan, the Planning Team developed a matrix intended to be a planning tool for hazard assessment purposes to help Eastham determine its most likely and most potentially damaging natural hazards. The Planning Team applied their best professional judgment and solicited information and knowledge from various sources (historical data and Town employees) to consider as comprehensively as possible, potential natural hazards in Eastham.

The range of risks identified by the Planning Team posing potential damage to life and property include:

- Wind (from hurricanes, nor'easters, tornadoes)
- Flood (from coastal storm surge, storm tides & wave action, erosion, and sea level rise)
- Shoreline erosion (from shoreline change)
- Wildfire
- Snow and ice (severe winter storms)
- Earthquakes
- Drought

Hazard Rating

In order to establish the potential degree of impact of the identified hazards within Eastham, the Planning Team applied a rating system to evaluate the location (geographic extent), frequency of occurrence and magnitude/severity of each identified hazard. A Hazard Rating System (Table 2) was applied to the hazards identified above. Each hazard's ranking was determined by adding the rating scores for location, frequency and magnitude/severity (Table 3).

Table 2: Hazard Ranking

Location	
1=small	(isolated to a specific parcel, building, intersection, or neighborhood)
2=medium	(occurring in multiple locations across town during one event)
3= large	(affecting a significant portion of town during one event)
Frequency of Occurrence	
0=unlikely	(less than 1% probability in the next 100 years)
1=possible	(between 1 – 10% probability in the next year; or at least one chance in next 100 years)
2=likely	(between 10-100% probability in the next year; or at least one chance in next 10 years)
3=highly likely	(Near 100% probability in the next year)
Magnitude/Severity	
1=limited	(injures and/or illnesses are treatable with first aid; minor "quality of life" loss; shutdown of critical facilities and services for 24 hours or less; property severely damaged < 10%)
2=significant	(injuries and/or illness do not result in permanent disability; shutdown of several critical facilities for more than one week; property severely damaged <25% and >10%)
3=critical	(injuries and/or illnesses result in permanent disability; complete shutdown of critical facilities for at least two weeks; property severely damaged <50%, >25%)
4=catastrophic	(multiple deaths; complete shutdown of facilities for 30 days or more; property severely damaged >50%)

Source: Cape Cod Commission

Table 3: Hazard Identification Matrix – Ranked by Hazard Score

Natural Hazard:	*Location* *RATE:* *1=small* *2=medium* *3= large*	*Frequency of Occurrence* **RATE:** *0=unlikely* *1=possible 2=likely* *3=highly likely*	*Magnitude / Severity* *RATE:* *1=limited* *2=significant* *3=critical* *4=catastrophic*	*Hazard Score*
Flood	2	3	4	**9**
Wind	3	2	2	**7**
Chronic Erosion	2	3	2	**7**
Fire	2	2	2	**6**
Snow & Ice Accumulation	3	1	2	**6**
Geologic	3	0	1	**4**
Drought	2	1	1	**4**
Sea Level Rise	2	1	1	**4**

Section 3: Vulnerability Assessment

Critical Facilities and Infrastructure

To establish a planning baseline, the Planning Team used the "Risk and Vulnerability Assessment Map / Local Critical Facilities Map" (Appendix Map 1) generated by the CCC to review locations of critical facilities and infrastructure in the context of Hazard Mitigation Planning. As its first steps the Planning Team reviewed and commented on a draft map created by the CCC. Thirteen (13) critical facilities are located within Eastham falling into eight (8) of the twelve (12) functional categories identified for the region (Table 4).

Table 4: Eastham's Critical Facilities

CRITICAL FACILITY OR INFRASTRUCTURE	ADDRESS	SLOSH (Y/N)	FIRM (Y/N)	WILDFIRES (Y/N)
Emergency Operations Center (Police Station)	2550 Rte.6	NO	NO	NO
Eastham Town Hall	2500 Rte. 6	NO	NO	NO
Nauset Regional High School	100 Cable Rd.	NO	NO	**YES**
Eastham Fire Department	2520 Rte. 6	NO	NO	NO
Council On Aging	1405 Nauset Rd.	NO	NO	**YES**
Department of Public Works / Transfer Station	555 Old Orchard Rd.	NO	NO	NO
Public Library	190 Samoset Rd.	**YES**	**YES**	NO
Eastham Elementary/ After School Program	200 Schoolhouse Rd.	NO	NO	**YES**
The Children's Place	Foster Ave.	NO	NO	**YES**
Nauset Kennels	2685 Nauset Road	NO	NO	NO
Eastham Veterinary Hospital	725 State Highway	NO	NO	NO
Salt Pond Visitors Center	Nauset Road	NO	NO	NO
NEEDS Building	Ocean View Dr.	NO	NO	NO

Of the thirteen (13) critical facilities identified, only one of the parcels was identified in a Special Flood Hazard Area (SHFA) and SLOSH zone. However, it should be noted that actual facility, the Library, is located above the floodplain indicated on the FIRM, only lower portions of the lot directly adjacent to Depot Pond area subject to storm flooding. In a 100 year storm event access to the facility would not be compromised. Additionally, the Library is not designated as a shelter location. In a widespread flooding event all of Eastham's critical facilities would not be expected to be inundated with water.

The CCC conducted an analysis to assess wildfire hazards for the Region. Undeveloped areas, unfragmented forest land greater than forty (40) and marshes greater than three (3) acres, were evaluated in relation with their proximity to developed land uses. This mapping exercise identified areas of Wildfire Risk and the Wildland/Urban Interface (see Appendix Map 4). A total of four (4) of Eastham's thirteen (13) critical facilities are located in areas susceptible to wildfires. Nauset Regional High School, Eastham Elementary School and the Children's Place are all located in an area identified as Wildfire Risk. Eastham's Council on Aging is located at a Wildland/Urban Interface.

Vulnerability Analysis

The Planning Team used the map identifying critical facilities and infrastructure to review potential vulnerabilities during the natural hazard events identified and described in *Section 2: Analysis and Risk Assessment*. To clearly and efficiently evaluate all of the potential natural hazards identified by the Planning Team, the location and extent of possible specific areas were identified. A descriptive locations chart was developed that grouped potential natural hazards, identified cause and effects of each hazard and displays areas susceptible to damage.

After identifying types and areas of risk, a vulnerability analysis was conducted to help determine the unprotected points in Eastham. The Planning Team's analysis examined potential vulnerabilities in the built environment, such as structures, utilities, roads, culverts and bridges. Additionally, environmental vulnerability, such as beaches that can suffer from erosion was evaluated.

Existing Shelters

Eastham has a total of five (5) emergency shelter facilities located within Town boundaries, with a total capacity for 1,200 persons. None of the shelters are located in areas prone to flooding. However, two (2) of the five (5) shelters are located in potential wildfire hazard areas.

Table 5: Eastham Public Shelter Facility Capacities

Facility Name	Flood Potential	Wildfire Hazard	Capacity
Council on Aging	No	**Yes**	25
Eastham Town Hall	No	No	100
Eastham Police Station	No	No	25
Eastham Fire Station	No	No	50
Nauset Regional High School	No	**Yes**	1,000
		Total Shelter Capacity =	**1,200**

Shelter Adequacy Analysis

Using the methodology developed in the *Southern Massachusetts Hurricane Evacuation Study (USACE and FEMA, 1997)* which 1990 US Census value for permanent population as a baseline, the Planning Team adjusted the figures in the analysis to reflect 2000 US Census population value and Eastham Police Department's seasonal population estimate of 30,000 for 2004. Additionally, new shelter capacity has come on-line since 1997.

Revised vulnerable population values were determined by applying more recent permanent and seasonal values to the proportions from the original analysis. Vulnerable populations were calculated for two hurricane scenarios (weak and severe). Additionally, revised evacuating population values were also generated for both hurricane scenarios. The new values are highlighted by bolding in Tables 6 and 7.

Table 6: Vulnerable Populations – Under Weak and Severe Hurricane Scenarios

Weak Hurricane Scenario						
Population				**Vulnerable Population**		
Census	**Permanent**	**Seasonal**	**Total**	**Permanent**	**Seasonal**	**Total**
1990	4,460	15,930	20,390	850	2,590	3,440
2000	**5,450**	**24,550**	**30,000**	**1,039**	**3,991**	**5,030**
Severe Hurricane Scenario						
Population				**Vulnerable Population**		
Census	**Permanent**	**Seasonal**	**Total**	**Permanent**	**Seasonal**	**Total**
1990	4,460	15,930	20,390	1,380	4,060	5,440
2000	**5,450**	**24,550**	**30,000**	**1,686**	**6,257**	**7,943**

Table 7: Evacuating Populations – Under Weak and Severe Hurricane Scenarios

Weak Hurricane Scenario						
Population				**Vulnerable Population**		
Census	**Permanent**	**Seasonal**	**Total**	**Permanent**	**Seasonal**	**Total**
1990	4,460	15,930	20,390	850	2,590	3,440
2000	**5,450**	**24,550**	**30,000**	**1,039**	**3,991**	**5,030**
Severe Hurricane Scenario						
Population				**Vulnerable Population**		
Census	**Permanent**	**Seasonal**	**Total**	**Permanent**	**Seasonal**	**Total**
1990	4,460	15,930	20,390	4,900	750	5,650
2000	**5,450**	**24,550**	**30,000**	**5,988**	**1,156**	**7,144**

To evaluate the adequacy of shelter capacity in Eastham, the Planning Team determined that a hurricane would be the best indicator as that type of event would most likely result in large scale evacuation. To contrast the Town's existing shelter capacity for 1,200 persons with the likely utilization of such facilities under weak and severe hurricane scenarios, again a methodology developed in the *Southern Massachusetts Hurricane Evacuation Study (USACE and FEMA, 1997)* was updated to reflect values from the 2000 US Census and Eastham Police Department to account for the increased population since the analysis was originally conducted in 1997.

Under the weak hurricane scenario, an excess capacity of 570 persons was projected. An excess capacity of 150 persons was projected under a severe hurricane scenario. While, excess shelter capacity appears to exist, it should be noted that Nauset Regional High School (NRHS) is a regional facility that could draw persons from outside of Eastham. During a major flooding or storm surge event, access to NRHS would not be expected to be restrained to the north, southern portions of Wellfleet in particular.

Table 8: Shelter Utilization Analysis – Under Weak and Severe Hurricane Scenarios

Weak Hurricane Scenario					
Census	**Surge Vulnerable Residents**	**Non-surge Vulnerable Residents**	**Total Utilization**	**Capacity**	**Capability**
1990	440	60	500	125	(375)
2000	**538**	**92**	**630**	**1,200**	**570**
Severe Hurricane Scenario					
Census	**Surge Vulnerable Residents**	**Non-surge Vulnerable Residents**	**Total Utilization**	**Capacity**	**Adequacy**
1990	670	150	820	125	(695)
2000	**819**	**231**	**1,050**	**1,200**	**150**

Repetitive Loss Properties

A repetitive loss property is any property, which the National Flood Insurance Program (NFIP) has paid two or more flood claims of $1,000 or more in any, given 10-year period since 1978. Specific property information is confidential, but within the Town of Eastham there have been six (6) properties that meet FEMA's definition of repetitive loss through December of 2002. All of the properties are single-family homes. Three of the latest claims were in 1993. Of the total six repetitive loss properties, three (3) properties have made four (4) claims, two (2) properties have made three (3) claims, and one (1) property has made two (2) claims. The property owners were paid a total of $241,719 for an average $40,286 per property losses due to building damage.

As of December 31, 2002 there were 165 flood insurance policies in effect in Eastham, with a total value of $27,701,600 and the written premium in-force amount was $71,026. Through December 31, 2002, 62 total losses were reported, with 12 of those being closed without payment. The remaining 50 losses resulted in total payments of $387,816.

Quantification of Potential Losses

The Planning Team desired to conduct a quantification of potential losses and estimation of potential losses for the PDM, however, due to data processing limitations, this analysis could not be conducted for this plan. As the Town's Geographic Information System (GIS) capabilities expand, these estimates will be calculated. With the development of a building footprint GIS "layer", the estimation of potential losses at varying degrees of storm surge, wind, and stormwater hazard severity, as well as specific impacts on critical facilities will be evaluated.

Descriptive Locations

As part of its comprehensive analysis, the Planning Team developed a Descriptive Location Chart (Table 9) to identify specific vulnerable locations. The analysis included evaluating the cause and effect associated with each natural hazard identified in the PDM plan and potential resulting problems and their expected specific locations.

Table 9: Descriptive Location Chart

NATURAL HAZARD	CAUSE (▶) & EFFECT (●)	DESCRIPTIVE LOCATION
FLOOD	▶ **Natural Inundation** in the floodplain (caused by coastal storms; winter storms; northeasters; hurricanes) ● Coastal Flooding ● Episodic Erosion ● River Flooding ● Pond Flooding ● Infrastructure Failure ▶ **Infrastructure Failure** (caused by coastal storms; winter storms; northeasters; hurricanes; ice/snow melt) ● Bridge Failure ● Culvert Failure ● Dam Failure ● Storm Drain Failure ● Dike Failure	**Areas of Coastal Flooding** ➢ Dyer Prince Road ➢ Bridge Road (Boat Meadow Area) ➢ Route 6 (Governor Prence Area) ➢ Samoset Road (First Encounter Beach) ➢ Steele Road (Cooks Brook Beach Vicinity) ➢ Undeveloped parcels in Boat Meadow area **Areas of Episodic Erosion** ➢ Nauset Light Road /Nauset Light Beach Vicinity ➢ Coast Guard Beach Vicinity ➢ Cape Cod Bay Shoreline **Areas of Pond Flooding** ➢ Northeast and Southwest bank of Great Pond ➢ North and south banks of Long Pond ➢ Southwest bank of Muddy Pond **Areas of River Flooding** ➢ Rock Harbor Creek along Dyer Prince Road ➢ Boat Meadow Creek at intersection with Bridge Road ➢ Herring River at intersection with Bridge Road **Deficient Infrastructure** ➢ Culvert/crossing at Hatches Creek/Massasoit Road ➢ Culvert/crossing at Cole Brook/Herring Brook Road ➢ Culvert/crossing at Herring River/Herring Brook Road
WIND	▶ **Hurricanes** ● Roofs Blowing Off ● Trees Downed ▶ **Northeasters** ● Roofs Blowing Off ● Trees Downed ▶ **Tornadoes** ● Roofs Blowing Off ● Trees Downed	**Roof Damage** - Residences in close proximity to: ➢ Atlantic Ocean ➢ Nauset Estuary ➢ Town Cove ➢ Cape Cod Bay **Trees Downed** - Locations proximal to wind activity: ➢ Town Wide ➢ Great Pond (northern shore) ➢ Long Pond (southern shore)
FIRE	▶ **Drought** ● Wildfire ▶ **Lightning Strikes** ● Wildfire	**Wildfire** – Developed land / forested area interfaces: ➢ Residences within and adjacent the National Seashore ➢ Nauset Regional High School ➢ Undeveloped areas within National Seashore ➢ Residences adjacent to undeveloped open space ➢ Undeveloped open space areas

Table 9: Descriptive Location Chart (continued)

NATURAL HAZARD	CAUSE (▶) & EFFECT (●)	DESCRIPTIVE LOCATION
GEOLOGIC	▶ **Earthquakes** ● Structural Damage ● Loss of Land ▶ **Landslides** ● Loss of Land ▶ **Sink Holes** ● Loss of Land ▶ **Tsunamis** ● Loss of Land ● Structural Damage ● Wave Inundation	**Structural Damage** – Locations proximal to seismic activity: ➢ Buildings and Structures ➢ Infrastructure **Loss of Land** – Atlantic Coastal Bluffs ➢ Nauset Light Road (northern segment) ➢ Nauset Light Beach Area ➢ Ocean View Drive Area ➢ Coast Guard Beach Area **Wave Inundation** – Following wave prone areas: ➢ Atlantic Shoreline ➢ Cape Cod Bay Shoreline ➢ Low lying coastal areas
OTHER	▶ **Snow & Ice Accumulation** ● Street flooding from melt ● Impassable roads from snow ● Structural damage ▶ **Chronic Erosion** ● Eroding shoreline/ acreage losses ▶ **Sea Level Rise** ● Eroding shoreline/ acreage losses ▶ **Sediment Deposition** ● Navigation restriction ▶ **Drought** ● Reduced water availability	**Street Flooding** – Compromised drainage: ➢ Inadequate/obstructed catch basins and culverts **Structural damage** – Town wide potential ➢ Roof cave-in **Impassable Roads** – Ability to plow ➢ State maintained ➢ Town maintained (particularly Bridge Road/Boat Meadow and Great Pond Road/Great Pond areas) ➢ Privately owned **Eroding Shoreline** – Following adjacent marine areas: ➢ Un-armored private properties along Cape Cod Bay ➢ Town-owned Cape Cod Bay Beaches ➢ Atlantic Coastline **Navigation Restriction** – Following navigational areas: ➢ Nauset Inlet ➢ Rock Harbor **Reduced Water** – Town wide potential ➢ Private/Community wells ➢ Reduced surface water levels (freshwater)